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Characteristics, treatments, and management for disposal of sanitary wastewater in South Pars Gas processing plants

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ABSTRACT

Improper or inadequate treatment, handling, and disposal of sanitary wastewater can have far reaching impacts on the environment. These impacts are the reasons for management and regulation of South Pars Gas processing plants. Foaming, high suspended solids, high biodegradable material and low pH are the main causes of pollution problems in the sanitary wastewater treatment (activated sludge process) of a gas processing plant. Recent inspection of the sanitary treatment package showed that significant foaming has occurred in inlet Sump and aeration Tank of the unit as well as increasing BOD (biochemical oxygen demand) of effluent stream. The object of the present investigation is (a) to focus on the performance assessment of activated sludge process and potential reasons of pollution that have been gained from observations and laboratory results in South Pars Gas processing plant (b) to discuss the effects of these reasons on the specification of effluent wastewater, (c) to analyze operational management and modification of current activated sludge system and (d) from the results suggest some techniques for pollution control in the plant.

1. Introduction

Water pollution issues now dominate public concerns about national water quality and maintaining healthy ecosystems. Although a large investment in water pollution control has helped reduce the problem, many miles of streams are still impacted by a variety of different pollutants. This, in turn, affects the ability of people to use the water for beneficial purposes (Neff, 2002). Good quality water is often required in order to comply with environmental standards and regulations. Additionally, in areas of limited water resources, water economics may dictate the possible reuse of wastewater effluent. Such requirements and considerations necessitate the efficient treatment of the wastewater for the removal of hazardous contaminants (USEPA; Tellez et al., 2002).

In South Pars Gas process plant, sanitary wastewater is treated by activated sludge process. Sanitary wastewater is a mixture of used water and wastes which are gathered from residential, commercial and official buildings. It also sometimes mixed with underground and surface water. The treated water can be used for irrigation or discharged directly to the sea. Gas process wastewater is not routed to sanitary wastewater treatment (Davoudi et al., 2014). Activated sludge is a biological process that utilizes microorganisms to convert organic components from wastewater into cell mass. The activated sludge is then separated from the liquid by clarification. The settled sludge is either returned or wasted. The activated sludge is commonly used as a wastewater treatment process because it is an effective and versatile treatment process and capable of a high degree of treatment (Martin, 1927; Richard, 1989).

The basic principle behind all activated sludge processes is that as microorganisms grow, they form particles that clump together. These particles (floc) are allowed to settle to the bottom of the tank, leaving a relatively clear liquid free of organic material and suspended solids. Described simply, screened wastewater is mixed with varying amounts of recycled liquid containing a high proportion of organisms taken from a clarifying tank, and it becomes a product called mixed liquor. This mixture is stirred and injected with large quantities of air, to provide oxygen and keep solids in suspension. After a period of time, mixed liquor flows to a clarifier where it is allowed to settle. A portion of the bacteria is removed as it settles, and the partially cleaned water flows on for further treatment (Andreadakis, 1993; Palm et al., 1980; Walker and Davis, 1977).

Many problems can develop in activated sludge operation that adversely affect effluent quality. The real heart of the activated sludge system is the development and maintenance of activated

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sludge that treats wastewater and which can be managed (Schuyler, 1995; Dal Ferro and Smith, 2007; Khatib and Verbeek, 2002).

Review of the literature shows that the activated sludge process has experienced operational problems since its beginning. Ardem and Lockett (1914a) did note increased turbidity and reduced nitrification with reduced temperatures. By the early 1920s continuous flow systems had to deal with the scourge of activated sludge, bulking and effluent suspended solids problems (Ardem and Lockett, 1914b). Also, Martin (1927) describes effluent quality problems due to toxic and/or high organic strength industrial wastes. Oxygen demanding materials would bleed through the process. More recently, Jenkins et al. (1993) discussed severe foaming problems in activated sludge systems.

Many researchers have shown biological treatment of petroleum refinery or some its compounds wastewater to be effective and efficient methods (Hansen and Davies, 1994; Bostick et al., 2002; Li et al., 2002; Faksness et al., 2004). Improved water management in a refinery can potentially reduce the volume and cost of raw water used in refinery operations. Furthermore, improved water management may result in reductions in wastewater flow or contaminant load or both. Lower flow and contaminant load may result in lower wastewater treatment operating and maintenance costs. Optimized water management may also reduce the mass of contaminants in the treated effluent, thus improving the quality of a wastewater discharge and ultimately the environmental impact of refinery's discharge. These practices are a collection of operational and procedural actions related to water management in a refinery (Jacobs et al., 1992; Pitre, 1984; Fillo et al., 1992; Utvik, 2003).

Since each refinery is uniquely configured, some of these practices may or may not be applicable based on the complexity of the wastewater treatment operations available at a particular site, availability of raw water sources, discharge configuration and type of receiving water body. This manual will enable a refiner to compare their operations with typical industry practices and develop a plan for optimizing water management in the refinery. The purpose of this study is to identify the various problems of sanitary wastewater treatment system in the South Pars Gas processing plant from both quantitative and qualitative viewpoint. Moreover, some operational management and process modifications made in the system were mentioned and relevant effectiveness was discussed. Also, some techniques for pollution control are recommended in the sanitary package.

2. Description of sanitary wastewater treatment unit

Sanitary treatment package separates solid from liquid by physical procedure and purifies the liquid by biological process. Sources of sanitary wastewater are lavatories, bathrooms, washstands and kitchen. The current sanitary package is designed to lower BOD (biochemical oxygen demand), TSS (total suspended solid) and COD (chemical oxygen demand) of raw sewage. The design capacity of this package is 50 m^3/day for 150 persons. Also, the flow rate and some characteristics of wastewater inlet to the package and after treatment are illustrated in Table 1.

Current sanitary wastewater treatment process (Fig. 1) contains an usual activated sludge system. At first, the sanitary wastewater is collected in the sewage Lift Sump. The wastewater is aerated in the Lift Sump to prevent solid particles settlement and pumped to the biological treatment. The aeration Tank exists at the beginning of the biological treatment. In this step, microorganisms convert dissolved BOD to suspended BOD by feeding from wastewater organic components and growth. The suspended BOD is the microorganism biomass that will be separated from water in the next steps. After that, the suspended particles, that contain biomass, are settled

Table 1
Characteristics of sanitary wastewater.

Criteria		Quantity
Population		150
Flow rate (m^3/h)	Normal	2.1
	Design	10
BOD_5 (ppm)	Influent	350
	Effluent	25 (50 max)
COD (ppm)	Influent	300
	Effluent	45 max
TSS (ppm)	Influent	
	Effluent	150 (350 max)

down in the Clarifier and clear treated water overflows. The settled sludge is separated and recycled to the aeration Tank or sludge Thickener. The Clarifier is equipped with a sludge skimmer that helps to sludge separation from clear water. The treated water is disinfected by hypochlorite injection. Finally, treated sanitary wastewater is sent to a storage Basin called irrigation Basin and then is sent to sea water. This water could be loaded to truck by a pump to use as irrigation water. Also, sludge from the bottom of Clarifier is concentrated in sludge Thickener in an anaerobic condition. Then, it is dried in solar drying Beds. This dry sludge is a strong fertilizer and could be used in agriculture or disposed in the environment.

3. Monitoring and performance assessment

Wastewater has physical, chemical, and biological characteristics. The suspended solid content of the sanitary wastewater is the single most important physical characteristic. The solid content affects the clarity, the color, and the overall esthetic quality of the water. Sanitary wastewater can have many biodegradable organics. Biodegradable organics are composed of proteins, carbohydrates, and fats. If sanitary wastewater is not properly treated, biodegradable organics can lead to lower dissolved oxygen levels in the water and septic conditions.

Experience shows that controlling the activated sludge process is still difficult for many plants. However, improved process control can be obtained systematically looking at the problems and their potential causes. Recent inspection of the sanitary wastewater treatment package showed that excessive foaming has occurred in the inlet Sump and aeration Tank of the section. According to the site visits and laboratory results, following results are summarized:

3.1. Foaming

As can be seen from Fig. 2, white foam is caused by high levels of surfactant such as detergents in the sanitary wastewater treatment unit. It seems that using very high load of surfactant during cleaning period is a main cause of this problem. The results of laboratory showed that the quality of performance of the sanitary treatment package has been changed due to the excessive use of detergents. Therefore, the theoretical COD removal was lower than actual COD removal. COD measures the amount of oxygen consumed by the oxidation of organic and reduced inorganic matters. Generally, the efficiency of activated sludge process is highly dependent on fluctuations in the quality of feed.

Figs. 3 and 4 indicate COD concentration of the influent and effluent streams of the sanitary package. As it is clear in Fig. 3, the amount of COD in the wastewater entering the aeration Tank is fluctuated frequently from January to September 2013 because of variation in the inflow stream. However, in the last two months (October and November), it has partly increased due to the